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SUMMARY

REGULARITY AND MECHANISM OF MARINE SEDIMENTATION

Part 1. BLACK SEA

N. M. Strakhov

This article deals with the regularity in the distribution of clastic materials, CaCO_3 , iron, manganese, phosphorus, and organic matter in the sediment of the Black Sea.

I. METHOD OF CALCULATING COMPONENTS OF MARINE SEDIMENTATION

The progress of knowledge of the mechanism of sediment accumulation in seas is impossible without a basic improvement in the method of quantitative evaluation of the course of the sedimentation process in relation to each component of the sediment.

The principal point of improvement is simple. In order to explain the mechanism of sediment accumulation, data must be gathered on the absolute amount of each component which has settled on one unit of area over the same period of time in different parts of the reservoir. Having arranged such data, it is easy to construct a map of the distribution of absolute amounts of each component on the bottom of the sea, to explain the sectors of maximal and minimal accumulation of each component, to compare such maps with each other

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for different components, to compare them with the hydrological and hydrochemical regime of the reservoir, and thus to disclose all observable regularities and basic factors which control the course of marine sediment accumulation in general.

To obtain the absolute amount of any component in each given point for some interval of time is not difficult. In order to do this, the width of a dry core sample corresponding to the desired interval of time and expressed in centimeters (h) is necessary. This figure is multiplied by the volumetric weight of the sediment (v) and by the number which expresses the percentage content of the studied component in the dry sediment (p); the product received (m) will express the desired mass in grams per sq cm:

$$m = h \cdot v \cdot p \text{ (g/sq cm).}$$

This very simple method demands, however, one essential preliminary condition. It is necessary that the calculations in all points of the basin be made for the same interval of time. In other words, the method demands an exact stratification of the sediment. Starting from some initial width of the sediment in some point, we must know precisely which width corresponds to it in all other points of the reservoir. This necessary premise of the method of absolute amounts greatly limits its practical use.

The author has calculated the amount of each component per unit of area of the bottom which has accumulated during its recent stage, i.e., the last 2,500 years. The thickness of recent Black Sea sediment is based upon the stratigraphy of silts which was worked out by the author and A. D. Arkhangel'skiy in 1928-29. Composition of recent sediments has been established by the author from data collected by 296 stations in the eastern and central parts of the sea. The analysis of the data obtained made it possible to establish the following regularity in the distribution of basic sedimentary components over the bottom of the Black Sea.

II. DISTRIBUTION OF TERRIGENOUS MATERIAL ON THE FLOOR OF THE BLACK SEA AND ITS DETERMINING FACTORS

The localization of absolute amounts of clastic particles (inreducible residue) on the bottom of the sea is characterized by a maximal accumulation (up to 100-300 gr per sq cm) in the littoral zones, and minimal accumulation (2-10 gr) in the halostatic central areas. The littoral zones (and halostatic areas) adjoining the mountainous parts of the continents (Asia Minor, Caucasian shore) are characterized by higher accumulation of clastic particles compared with the regions of the flat (platform type) continental area in the northwestern corner of the sea. The currents carrying mineral detritus which has been thrown into the sea complicate this picture. In some places clastic particles are pulled toward the center of the basin, causing the appearance of strips and tongues of increased clastic sediment accumulation intrusive in the pelagic areas of the sea. Inconstant currents running in one direction from Sinop to Novorossiysk and then in the opposite direction have created two such "tongues," one of which runs from Sinop to the northeast and the other from Novorossiysk to the southwest. On the other hand,

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the currents carrying pure water (for example, that coming out of Kerch Strait) are shown on the sea bottom by the appearance of strips and spots with a minimal accumulation of clastic particles.

III. DISTRIBUTION OF CLASTOPHILIC COMPONENTS (IRON, MANGANESE, PHOSPHORUS) AND FACTORS CONTROLLING THEIR LOCALIZATION IN THE SEDIMENTATION OF THE BLACK SEA

The distribution over the bottom of the Black Sea of absolute amounts of other basic components (CaCO_3 , organic matter, iron, manganese, phosphorus) coincides with the basic lines of distribution of clastic material (insoluble mineral residues). The greatest amounts of CaCO_3 , iron, manganese, phosphorus, and organic carbon are concentrated in the littoral zones of the sea, where the maximal accumulations of terrigenous particles are also found. In these zones the maximal concentrations of sedimentation of all these components generally coincide. The minimal amounts of CaCO_3 , iron, manganese, phosphorus, and organic carbon are concentrated in the central regions of the sea and, in general, also coincide.

The distribution of iron, manganese, and phosphorus has the greatest similarity to that of clastic material and therefore these elements have been united by the author into a clastophilic group. This similarity appears not only in the distribution of absolute amounts of these components over the floor of the sea, but also in the percentage content of these elements in the natural sediment. The diagram and tables given show that the relation of iron, manganese, and phosphorus to the clastic material in *Mytilus Modiola* phaseoline muds as well as in deep-set gray clay is practically the same. Relatively greater accumulation of the above clastophilic components is to be found only in pelagic calcareous limestones.

IV. DISTRIBUTION OF TALATTOPHILIC COMPONENTS (CaCO_3 , ORGANIC MATTER) AND FACTORS CONTROLLING THEIR LOCALIZATION IN SEDIMENTATION OF THE BLACK SEA

Calcite and organic matter are distinguished by the author into a talatophilic group. The similarity in the distribution of components of the talatophilic group (CaCO_3 and organic matter) to that of clastic material is not so definitely expressed, the amount of CaCO_3 and organic matter decreasing toward the center of the sea much more slowly than the absolute amount of the clastic material. This fact results in the relative accumulation of calcite and organic matter in pelagic parts of the sea and a higher percentage of their content in the muds. The similarity is limited only to the distribution of absolute amounts. The percentage characteristics of the composition of muds produce distribution curves of CaCO_3 and organic carbon which are sharply distinguished and almost the reverse of distribution curves of clastic material.

The degree of similarity in the distribution over the sea bottom of clastic, clastophilic, and talatophilic components bears a close relation to the ways of migration of these components in fluvial waters. Iron, manganese, and phosphorus are mainly transported in rivers by fine terrigenous silt, ionized and colloidal solutions being of considerably less importance, and it is precisely iron, manganese, and phosphorus which are distributed on the sea bottom with the greatest similarity to silicate clastic materials. For CaCO_3 , and especially for organic matter, the clastic form of transfer

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is less important. Either ionized (CaCO_3) or colloidal solutions (organic matter) are predominant, and the similarity in the distribution of these components with terrigenous material is less expressed. Thus, it can be said that the less the role played by the clastic form in fluvial transportation, the less the similarity in the distribution of this component over the sea bottom with that of the clastic silicate particles (insoluble mineral residue), and vice versa.

The differences in the distribution of clastophilic and talatophilic components of muds from that of clastic material are identical in all cases. Both the clastophilic and talatophilic components in the course of sedimentation accumulate relatively in the central parts of the sea. The relative accumulation of iron, manganese, and phosphorus is much more weakly expressed than accumulation of CaCO_3 and organic matter. In other words, on a profile from the periphery of the sea to the center, the sedimentation of clastic material proceeds somewhat more rapidly than the precipitation of iron, manganese, and phosphorus, and the sedimentation of the latter is more rapid than that of CaCO_3 and organic matter. This regularity may be expressed as follows: the greater the role played by the ionized form in fluvial transportation of any component, the greater will be the relative accumulation of this component in the sedimentation of the pelagic parts of the sea. Precisely these movements of masses of some components relative to others in a pelagic direction cause that change of the relative chemical composition of sea muds which we observe in actuality.

Apart from the knowledge of the enumerated regularities, an evaluation of the feasibility of the percentage method as a method of studying the mechanism of marine sedimentation is essential for further analysis. Therefore, a brief comparison of the results of the percentage method and the absolute amount method is made.

From the data it is seen that the percentage method as a general rule reflects the same basic general tendencies in the distribution on the bottom of the basin of terrigenous material, showing regions of preeminent sedimentation (littoral zones of the sea) and areas of impoverished sedimentation (pelagic zones of the sea). But the percentage method does not give the exact amount of terrigenous material which is in some part of the sea, nor even an exact comparison of these amounts. All — even the very strongest — variations in the intensity of accumulation of terrigenous material are reflected by the percentage method in exceptionally weak form. To illustrate this weakness, it is sufficient to show, for example, that the percent of terrigenous material from *Mytilus Modiola* silt to lime silt decreases from 75 to 28 percent (i.e., less than three times), while the actual amount of clastic particles decreases from 200-300 to 2-4 gr per sq cm. This, of course, is still not the limit of the leveling. The same holds with regard to elements of the clastophilic group. For each of them the percentage method also as a general rule reflects the tendencies in the spatial localization of masses inside the reservoir, but it cannot give the characteristics of the real magnitudes of these masses. The comparison of the conduct of two different elements of the clastophilic group (for example, manganese, iron, and phosphorus) or the comparison of the distribution on the ocean bottom of all clastophilic groups and clastic material is a different matter. Such a comparison gives very exact results and makes it possible to explain the role which other component parts of the sediment play in the sedimentation of one of the components.

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The percentage method is absolutely inapplicable to analysis of the process of sedimentation of talatophilic components, organic matter, and carbonates. An increase (or decrease) of the percentage content of their components in natural sedimentation does not in the least denote a concentration (or deconcentration) of their actual amounts in the same or some other area of the sea. Here, even general tendencies of the spatial location are not given by the percentage method.

Thus, operating with the percentage method, we are in a position to analyze the sedimentation process only very incompletely. For a complete and objective picture of sediment accumulation, simultaneous application of the method of absolute amounts is necessary, and this will serve as a control for conclusions obtained from the percentage method.

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